WHAT IS CLAIMED IS:

1. A system for determining at least one bone property of a bone sample at at least one point, the system comprising:

a) a transmitting ultrasonic transducer and a receiving ultrasonic transducer, both transducers being confocal transducers, the transducers configured to receive the bone sample therebetween such that the confocal point of the transducers are located at the at least one point in the bone sample; and

b) a processor that initiates an ultrasonic signal from the transmitting transducers that is transmitted through the at least one point of the bone sample when positioned between the transducers and received by the receiving transducer, the processor receiving a signal reflecting one or more measures of the received ultrasonic signal, the processor determining at least one ultrasonic parameter for the at least one point of the bone sample based upon the transmitted and received ultrasonic signals, the processor further determining the at least one bone property at the point of the sample based upon the at least one ultrasonic parameter.

2. The system as in Claim 1, wherein the bone sample is a bone in a live human being.

3. The system as in Claim 1, wherein the confocal point of the transmitting and receiving transducers has a resolution equal to approximately 0.5 mm.

4. The system as in Claim 1, wherein the transmitting transducer emits ultrasonic signals at a frequency on the order of tens of megahertz.

5. The system as in Claim 1, wherein the system further comprises a three dimensional scanning stage on which the transmitting and receiving transducers are mounted, the

three dimensional scanning stage moving the transmitting and receiving transducers in three dimensions to move the confocal point of the transducers to correspond to a number of points in the bone sample when positioned between the transmitting and receiving transducers.

6. The system as in Claim 5, wherein, for each point in the bone sample corresponding to movement of the confocal point, the processor initiates an ultrasonic signal from the transmitting transducers that is transmitted through the bone sample and received by the receiving transducer, the processor receiving a signal reflecting one or more measures of the received ultrasonic signal, the processor determining at least one ultrasonic parameter for each point in the sample based upon the transmitted and received ultrasonic signals, the processor further determining the at least one bone property at each point of the sample based upon the at least one ultrasonic parameter for the point.

7. The system as in Claim 6, wherein the three dimensional scanning stage performs a discrete scan.

8. The system as in Claim 6, wherein the three dimensional scanning stage performs a continuous scan.

9. The system as in Claim 5, wherein each point in the bone sample is separated by approximately 0.1 mm.

10. The system as in Claim 1, wherein the at least one ultrasonic parameter determined for the at least one point of the sample are ultrasonic velocity (UV) and a measure of ultrasonic attenuation (UA).

11. The system as in Claim 10, wherein UV at the at least one point (x,y,z) of the sample is calculated by the processor as:

$$UV_{(x,y,z)} = v_m * w / (w - v_m * \Delta T)$$

where ΔT is the delay between the received ultrasound signal as passed through the bone sample and a reference ultrasound signal received without the sample positioned between the transducers, w is the thickness of bone and v_m is the velocity of ultrasound in ultrasound velocity in a medium in which the bone is immersed.

12. The system as in Claim 10, wherein the measure of UA is one selected from the group of broadband ultrasonic attenuation (BUA) and ultrasonic attenuation number (ATT).

13. The system as in Claim 12, wherein the measure of UA is BUA, where BUA at the at least one point (x,y,z) of the sample is calculated by the processor as the slope of the linear section of the ultrasound attenuation coefficient function, $UAC_{(x,y,z)}(f)$, where $UAC_{(x,y,z)}(f)$ is calculated from the fast fourier transform (FFT) of frequency f (as a function of time) for the received ultrasound signal $f_{bone}(t)$ as passed through the bone sample and a reference ultrasound signal $f_{ref}(t)$ received without the sample positioned between the transducers in accordance with the following equation:

$$UAC_{(x,y,z)}(f) = 20 \text{ Log } [(FFT (f_{ref}(t)) / (FFT (f_{bone}(t))].$$

14. The system as in Claim 12, wherein the measure of UA is ATT, where ATT at the at least one point (x,y,z) of the sample is calculated by the processor from the energy of the received ultrasound signal as passed through the bone sample and the energy of a reference ultrasound signal received without the sample positioned between the transducers in accordance with the following equation:

$$ATT_{(x,y,z)} = 10 * LOG [(\text{energy of reference signal})_{(x,y,z)} / (\text{energy of bone signal})_{(x,y,z)}].$$

15. The system as in Claim 12, wherein the at least one bone property determined at the at least one point is bone mineral density (BMD).

16. The system as in Claim 15, wherein BMD is determined at each point by at least one equation selected from the following group of three equations:

i) $BMD = e + f * UV + g * BUA$

ii) $BMD = a + b * UV + c * BUA + d * UV^2$

iii) $BMD = u + v * UV + w * ATT$,

where e,f and g; a, b, c and d; and u, v and w are constant coefficients, and UV, BUA and ATT are determined for the at least one point of the sample.

17. The system as in Claim 16, wherein i) e, f and g are linear regression constants predetermined by conducting a regression analysis between measurements of UV and BUA on bone specimens and BMD measurements on the bone specimens using conventional analysis; ii) a, b, c and d are non-linear regression constants predetermined by conducting a regression analysis between measurements of UV and BUA on bone specimens and BMD measurements on the bone specimens using conventional analysis; and iii) u, v and w are linear regression constants predetermined by conducting a regression analysis between measurements of UV and ATT on bone specimens and BMD measurements on the bone specimens using conventional analysis.

18. The system as in Claim 12, wherein the at least one bone property determined at the at least one point is Stiffness.

19. The system as in Claim 18, wherein Stiffness is determined by at least one equation selected from the following group of three equations:

i) $Stiffness = l + m * UV + n * BUA$

ii) $\text{Stiffness} = h + i * UV + j * BUA + k * (UV)^2$

iii) $\text{Stiffness} = p + q * UV + r * ATT$

where l, m and n; h, i, j and k; and p, q and r are constant coefficients, and UV, BUA and ATT are determined for the at least one point of the sample.

20. The system as in Claim 19, wherein i) l, m and n are linear regression constants predetermined by conducting a regression analysis between measurements of UV and BUA on bone specimens and Stiffness measurements on the bone specimens using conventional analysis; ii) h, i, j and k are non-linear regression constants predetermined by conducting a regression analysis between measurements of UV and BUA on bone specimens and Stiffness measurements on the bone specimens using conventional analysis; and iii) p, q and r are linear regression constants predetermined by conducting a regression analysis between measurements of UV and ATT on bone specimens and Stiffness measurements on the bone specimens using conventional analysis.

21. A method for determining at least one material property of a material sample at a point of interest, the method comprising the steps of:

a) emitting an ultrasonic signal such that it focuses at a confocal point;

b) positioning a material sample so that the ultrasonic signal passes through the material sample and such that the point of interest of the material sample lies within the confocal point of the ultrasonic signal;

c) receiving the ultrasonic signal after it passes through the material sample;

d) determining at least one ultrasonic parameter for the point of interest of the material sample based upon the transmitted ultrasonic signal and the received ultrasonic signal; and

e) determining the at least one material property at the point of interest of the sample based upon the at least one ultrasonic parameter.

22. The method as in Claim 21, wherein the confocal point is not greater than approximately 0.5 mm.

23. The method as in Claim 22, wherein the method further includes the steps of:

f) repositioning the confocal point to a new point of interest in the material sample; and

g) repeating steps a-e for the new point of interest in the material sample.

24. The method as in Claim 23, wherein steps a-g are repeated for an array of points of interest in the material sample, the array comprising a volume.

25. The method as in Claim 24, wherein points in the array are separated by approximately 0.1 mm.

26. The method as in Claim 22 wherein determining at least one ultrasonic parameter for the point of interest of the material sample comprises determining the ultrasonic velocity (UV) and a measure of ultrasonic attenuation (UA) for the point of interest.

27. The method as in Claim 22, wherein determining the at least one material property at the point of interest of the sample comprises determining at least one of elasticity, density, shear strength and tensile strength.

28. The method as in Claim 22, wherein the material sample comprises a bone sample.

29. A system for determining at least one material property of a material sample at at least one point, the system comprising:

a) a transmitting ultrasonic transducer and a receiving ultrasonic transducer,

both transducers being confocal transducers, the transducers configured to receive the material sample therebetween such that the confocal point of the transducers are located at the at least one point in the material sample; and

b) a processor that initiates an ultrasonic signal from the transmitting transducers that is transmitted through the at least one point of the material sample when positioned between the transducers and received by the receiving transducer, the processor receiving a signal reflecting one or more measures of the received ultrasonic signal, the processor determining at least one ultrasonic parameter for the at least one point of the material sample based upon the transmitted and received ultrasonic signals, the processor further determining the at least one material property at the point of the sample based upon the at least one ultrasonic parameter.

30 A method for determining a bone quality index at a point in a bone sample using ultrasound, the method comprising the steps of:

a) determining the broadband ultrasound attenuation (BUA) of an ultrasound signal passing through the point of the sample;

b) determining the Stiffness of the point of the sample from the ultrasound signal; and

c) calculating the bone quality index according to the equation:

$$\text{Bone Quality Index} = 0.7\ \text{BUA}/\beta + 0.3\ \text{Stiffness}/\tau$$

where β is a BUA normalization coefficient, and τ is a Stiffenss normalization coefficient.